§14. Development of Image Reconstruction Algorithm for 3D Bolometric Imaging System of LHD

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An infrared imaging video bolometer (IRVB) system is being arranged on LHD [1, 2] as an effective tool for measuring the radiated power from the plasma. The IRVB is a pinhole camera using a foil as a 2D absorber of radiation. Currently, three IRVBs are operating on Ports 10, 6.5-U and 6-T as illustrated in Fig. 1, and three additional IRVBs will be installed in near future. If one assumes the helical symmetry of the plasma that repeats every half period (18°) of the magnetic field in LHD, the 3D tomographic image reconstruction of the emission will be feasible by considering all the cameras fields of view as projected on one half period.

The primarily important work for tomography is to calculate the projection matrix regarding the geometry of the lines of sight of cameras. This difficult work of calculation using the 3D CAD of LHD has started. Then, the next goal that we aim is to achieve a numerical simulation on impurity radiation phantoms that are obtained using the software EMC3-Eirene.

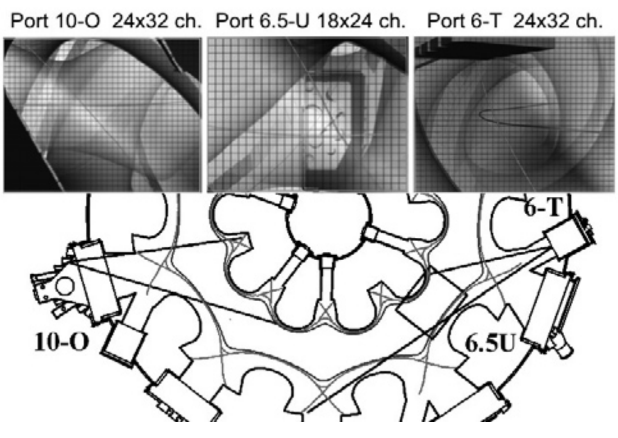

Fig. 1 Fields of view of IRVBs that were installed on three observation ports of LHD (Lower); 2D CAD images of the interior of LHD that should be obtained with the IRVB cameras (Upper). The number of channels (pixels) is shown for each camera.

This planned 3D image reconstruction of the IRVB will be done for about 5×10^4 voxels in the plasma volume of one half period. Thus, one meets a linear inverse problem much larger in size than the conventional plasma imaging. With this motivation, a study is made to improve the neural network collocation method (NNCM) [3]. The NNCM is essentially a series expansion method that is nonlinear with adaptive basis functions of the plasma image and, will have an advantage of small computational complexity even for a 3D reconstruction. However, as long as the sigmoid activation function is used, the adaptability does not appear to be high enough [4].

With this regard, an interest is taken on the generalization of NNCM to the radial basis function (RBF) type of neural network, whose scheme is shown in Fig. 2. In the 3-layered perceptron, the neurons with internal states u_i in the middle layer are equipped with Gaussian activation functions that are provided with heights h_i, central positions (c_{xi}, c_{yi}) and widths w_i. Driven by the position coordinates (x, y), the perceptron outputs the plasma image (emission intensity distribution) in the form of a linear combination of Gaussian spatial functions.

A new algorithm was implemented: that is, the parameters h_i, (c_{xi}, c_{yi}) and w_i were appropriated by referring the image that was ART-reconstructed from residuals (fitting errors), and the number of neurons N was increased one-by-one in order to get a good reconstruction. Concerning the bolometer tomography in the semi-tangential plane of LHD, it was seen that this algorithm of neuron addition converged well, and that the adaptability to plasma images was considerably higher in comparison with the conventional NNCM. The details can be seen in [5].

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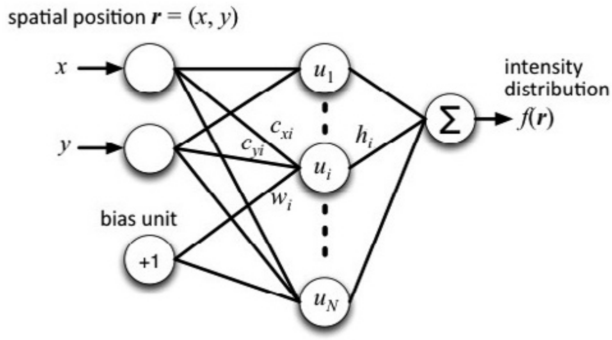

Fig. 2 Configuration of the RBF neural network for 2D reconstruction. In the 3D case, another neuron that receives the z coordinate is added to the input layer in order to feed the Gaussian position c_{zi} to the i-th neuron in the middle layer.

1) Peterson, B.J. et al.: Rev. Sci. Instrum. **72** (2001) 923.
2) Drapiko, E., Peterson, B.J. et al.: Rev. Sci. Instrum. **81** (2010) 10E116.
3) Ma, X.F., Fukuhara, M. and Takeda, T.: Nucl. Instrum. Meth. Phys. Res. **A 449** (2000) 366.
4) Iwama, N., Teranishi, M. et al: Ann. Rep. NIFS 2009, p. 178.
5) Teranishi, M., Iwama, N., Tamura, N., Peterson, B.J. and Kostryukov, A.Yu.: Proc. of FAN 2010, OS11 (6 pages), (Tokyo Metropolitan Univ., Minami Osawa, Sept. 2010)